International Journal of Electronics,
Communication & Instrumentation Engineering
Research and Development (IJECIERD)
ISSN(P): 2249-684X; ISSN(E): 2249-7951
Vol. 5, Issue 1, Feb 2015, 9-18

COLOUR SPACES EFFECTS ON JOINT DCT-DWT BASED DIGITAL IMAGE WATERMARKING

SURBHI[1], RAJESH KOCHHER[2] & ASHISH MALHOTRA[3]

[1]Research Scholar, Department of ECE, DAVIET, Punjab, India

[2]Assistant Professor, Department of IT, DAVIET, Punjab, India

[3]Assistant Professor, Department of ECE, DAVIET, Punjab, India

ABSTRACT

The aim of this work is to provide a digital watermarking technique using joint DCT-DWT algorithm which have always been realized in RGB colour space. In this study, a secure DCT-DWT based image watermarking technique is proposed and tested in seven colour spaces viz. RGB, HSV, HIS, YCbCr, YUV, YIQ and CIELab to determine which colour space is more effective in watermarking algorithms. In the proposed scheme, a watermark image is embedded into original cover image which is been wavelet decomposed followed by block based DCT of intended colour space. The experimental results shows that the proposed approach is oblivious and can successfully recover cover image with acceptable visual quality.

KEYWORDS: Image Watermarking, Discrete Wavelet Transform, Discrete Cosine Transform, Color Space

INTRODUCTION

The success of internet allows for the prevalent distribution of multimedia data in an effortless manner. Due to the open environment of internet downloading, copyright protection introduces a new set of challenging problems regarding security and illegal distribution of privately owned images. One potential solution for declaring the ownership of images is to use 'watermarks' [39]. Watermarking is a technique used for labelling digital pictures or images by hiding secret information called watermarks in the images. Indeed, there are a number of desirable characteristics that a watermarking technique should exhibit i.e. the watermarking scheme must meet the requirements of good imperceptibility, strong robustness and high-level security [1, 3, 5].

Research conducted for the purpose of this work indicate that watermark can be embedded onto the signal in spatial domain or frequency domain. Our research relies on watermarking in frequency domain using joint DCT-DWT as it has drawn extensive attention for its improved performance of the watermarking algorithms that are based solely on either DWT or DCT.

Discrete Wavelet Transform

The basic idea of DWT in image processing is multi-differentiated decomposition of image into sub-image of independent frequency districts. The transform is based on small waves called wavelets of varying frequency. These wavelets are created by translations and dilations of a fixed function called Mother Wavelet. Application of DWT in 2D images divides the input image into four non-overlapping multi-resolution sub-bands by filters namely LL, LH, HL and HH. The sub-band LL is processed further to obtain next coarser scale of wavelet coefficients [7, 12].

Discrete Cosine Transform

The Discrete Cosine Transform represents an image as a sum of sinusoids of varying magnitudes and frequencies [5]. DCT helps to convert a signal from spatial representation into frequency representation. The popular block based DCT transform results in giving three frequency coefficients: low frequency sub-band, mid frequency sub-band and high frequency sub-band. Out of these sub-bands, mid frequency sub-band is considered to be the best for embedding watermark so as to not affect the image quality [2, 9].

Joint DCT-DWT Transform

The reason of applying the combination of the two transforms is based on the fact that joined transform could make up for the disadvantages of each other. The application of joint DCT-DWT results in higher imperceptibility and it also helps in choosing the most proper sub-band for watermark embedding.

Colour Spaces

A colour may be defined as the extension of grey scale and is considered as a key element for a number of image processing systems. In particular, colour space transforms have played a central role in image processing. A colour space is basically a mean of specifying colours and can be classified into three parts: HVS-based colour spaces (e.g. RGB, HSI, HSV etc.), application-specific (e.g. YCbCr, YIQ, YUV etc.) and CIE colour space (e.g. CIELab) [1, 3].

Within first category, the most widely used colour space in digital image watermarking is RGB (Red-Green-Blue) which is a natural scheme for representing real-world colour wherein each of the three channels is highly correlated with the other two. HIS (Hue Saturation Intensity) and HSV (Hue Saturation Value) are linear transformations of RGB colour space. The second category includes YCbCr which is a component colour space that breaks the visual information into black and white (Luma) signal and two colour components. The third category deals with CIE (Commission on Illumination) colour spaces for colour quality estimation. The CIELab provides a standard and approximate uniform colour space which corresponds to visual differences between the colours [1, 6, 38].

THE PROPOSED SCHEME

This study proposed a digital image watermarking scheme that uses joint DCT-DWT algorithm for embedding and extraction of watermark image from original cover image. The block diagram of the proposed watermarking approach is shown in Figure 1.

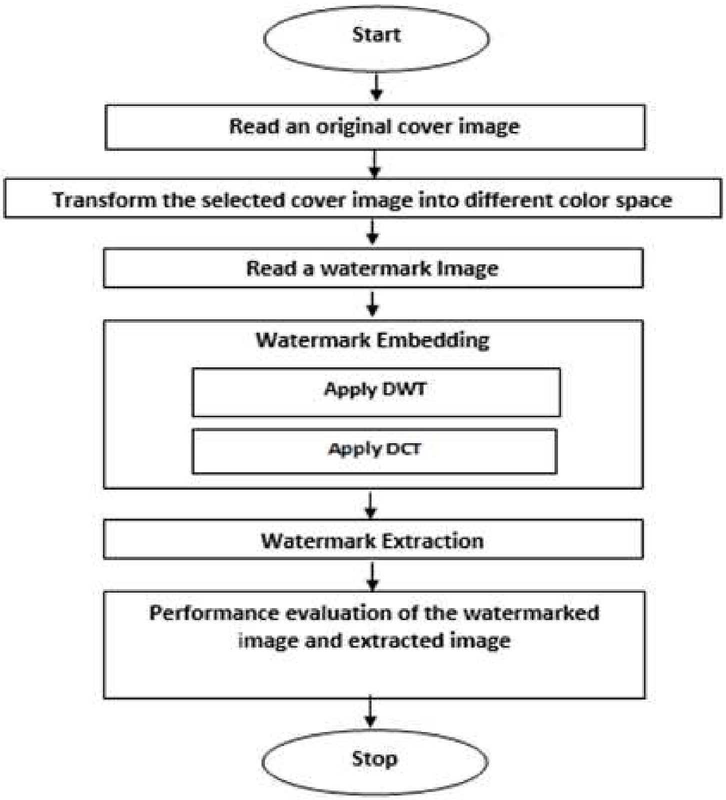

Figure 1: Block Diagram of the Proposed Watermarking Approach

Embedding Framework

In this framework, the watermark image will be embedded into the original cover image using Discrete Wavelet Transform (DWT) followed by Discrete Cosine Transform (DCT). The steps involved in the embedding of watermark image into LL2 coefficients of host image are described as follows:

Step1: Read the original cover image.

Step2: Convert the cover image from integer to double form.

Step3: Decompose the host image into discrete wavelets of different frequency using Haar Transform. The third level DWT component i.e. LL2 is taken as target sub-band for embedding the watermark image.

Step4: Apply block-based DCT on level-3 DWT components i.e. h_LL2 and w_LL2.

Step5: Scramble the DCT transformed components.

Step6: Perform IDWT and IDCT on all the decomposed coefficients.

Step7: Reconvert cover image from double to integer form.

Extraction Framework

In this framework, the original image will be recovered back from the watermarked image using Discrete Cosine Transform (DCT) followed by Discrete Wavelet Transform (DWT). The watermark extraction procedure is described in detail in the following steps:

Step 1: Read the watermarked image.

Step 2: Convert the watermarked image from integer to double form.

Step 3: Apply DCT on watermarked image to extract watermark image.

Step 4: Apply DWT using Haar Transform to get level-3 component i.e. LL2 on watermarked image to extract cover image.

Step 5: Scramble the DWT coefficients.

Step 6: Perform IDWT and IDCT.

Step 7: Reconvert the extracted watermark image to integer form.

RESULTS AND ANALYSIS

In this section, the results of the experiments are reported and their interpretation is given. To achieve high imperceptibility, the proposed image watermarking scheme was implemented and tested over different colour spaces to determine the best colour space for watermarking algorithms. Six famous images: Man, Baboon, Lena, Peppers, Bird and Sunflower shown in Figure 2(a-f) were taken as the cover images to embed a watermark image shown in Figure 2(g).

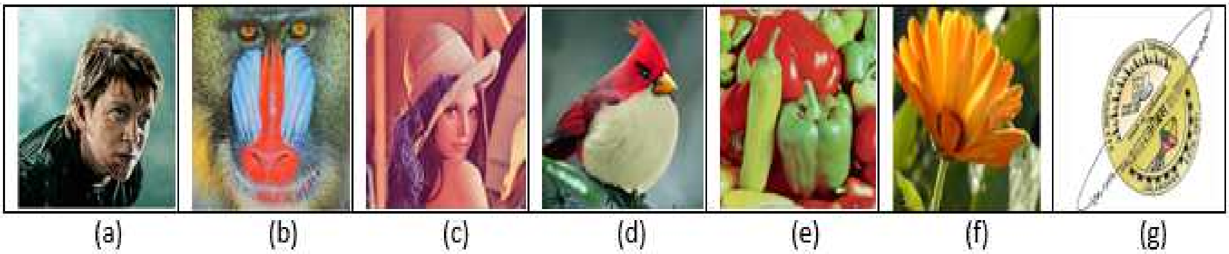

Figure 2: Six Famous Cover Images and a Watermark Image
(a) - (f) Cover Man, Baboon, Lena, Bird, Peppers and Sunflower Images
(g) Watermark Image

It is also mentioned that in all of the implementations, MATLAB R2012B software was used. After the watermark embedding and extraction process, the quality of watermarked images and original image was evaluated.

Experimental Results

The proposed method of watermarking achieved embedding the watermark with no visible change to the original image. As seen in Figure 3, for all the MATLAB images there is no evidence that could distinguish the original cover images (as shown in Figure 2) from the watermarked images.

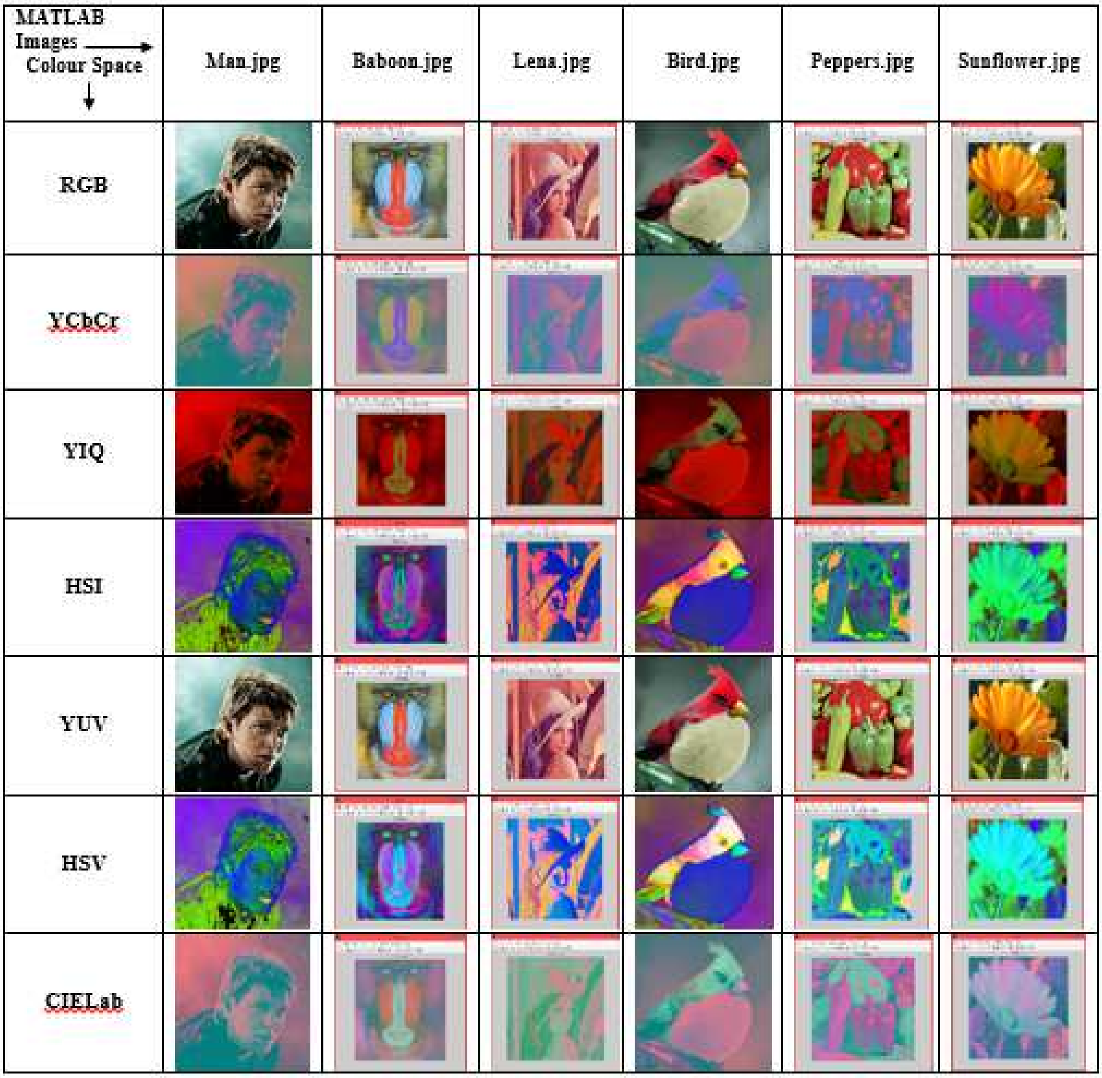

Figure 3: Watermarked Images in Different Colour Spaces

Tabular Results

To evaluate the quality of watermarked images; evaluation parameters like PSNR, MSE and RMSE are calculated. The values of these parameters describes that whether there is any change encountered in the original cover images after the watermark embedding and extraction process. Here we employee PSNR to indicate the transparency degree between the original cover image and the watermarked image.

Peak Signal to Noise Ratio (PSNR) is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation [6]. It is expressed in decibels (dB). A larger PSNR indicates that the watermarked image closely resembles the original cover image, meaning that the watermarking method makes the watermark more imperceptible. Table 1shows the results of PSNR valuesfor all the MATLAB images in their intended colour spaces. As seen in Table 1, RGB colour space has the highest PSNR value followed by YUV, HSV, YIQ, HSI, YCbCr and CIELab colour spaces respectively.

Table 1: PSNR Values of Watermarked Images in Different Colour Spaces

Color Space → / MATLAB Images ↓	RGB	YCbCr	YIQ	HSI	YUV	HSV	CIELab
man.jpg	95.84	92.39	93.81	93.82	93.84	93.82	91.94
Baboon.jpg	95.84	93.56	93.76	93.77	93.79	93.77	92.52
leena.jpg	95.84	92.78	93.70	93.70	93.72	93.71	92.07
bird.jpg	95.84	92.91	94.84	94.85	94.87	94.85	92.33
peppers.jpg	95.84	91.10	94.38	94.38	94.41	94.38	89.18
sunflower.jpg	95.84	90.02	94.03	94.01	94.04	94.01	88.16

Table 2: MSE Values of Watermarked Images in Different Colour Spaces

Color Space → / MATLAB Images ↓	RGB	YCbCr	YIQ	HSI	YUV	HSV	CIELab
man.jpg	4.48	6.32	5.48	5.48	5.46	5.48	6.61
Baboon.jpg	4.48	5.62	5.51	5.51	5.49	5.50	6.24
leena.jpg	4.48	6.08	5.54	5.54	5.53	5.54	6.52
bird.jpg	4.48	6.00	4.95	4.94	4.93	4.94	6.36
peppers.jpg	4.48	7.19	5.18	5.18	5.16	5.18	8.71
sunflower.jpg	4.48	8.01	5.37	5.37	5.36	5.37	9.65

Mean Square Error (MSE) measures the average of the square of the error. The error is the amount by which the pixel value of original image differs from the pixel value of modified image [6]. While the Root Mean Square Error (RMSE) measures the difference between the original cover image and the watermarked image. Lower the value of MSE or RMSE; lower the error and better the watermarked image quality. Table 2 shows the results of MSE values for all the MATLAB images in their intended colour spaces. As seen in Table 2, RGB colour space has the lowest MSE value. Table 3 shows the results of RMSE values for all the MATLAB images in their intended colour spaces. As seen in Table 3, RGB colour space has the lowest RMSE value.

Table 3: RMSE Values of Watermarked Images in Different Colour Spaces

Color Space → / MATLAB Images ↓	RGB	YCbCr	YIQ	HSI	YUV	HSV	CIELab
man.jpg	2.12	2.51	2.34	2.34	2.34	2.34	2.57
Baboon.jpg	2.12	2.37	2.35	2.35	2.34	2.35	2.50
leena.jpg	2.12	2.46	2.35	2.35	2.35	2.35	2.55
bird.jpg	2.12	2.45	2.22	2.22	2.22	2.22	2.52
peppers.jpg	2.12	2.68	2.28	2.28	2.27	2.28	2.95
sunflower.jpg	2.12	2.83	2.32	2.32	2.31	2.32	3.11

Graphical Results

Figure 4 shows that RGB colour space has the highest PSNR value which is 95.84 dB; after that respectively, YUV, HSV, YIQ, HSI, YCbCr and CIELab colour spaces have the greatest values. By comparing all the colour spaces, it is found that RGB colour space leads to the best watermark imperceptibility property.

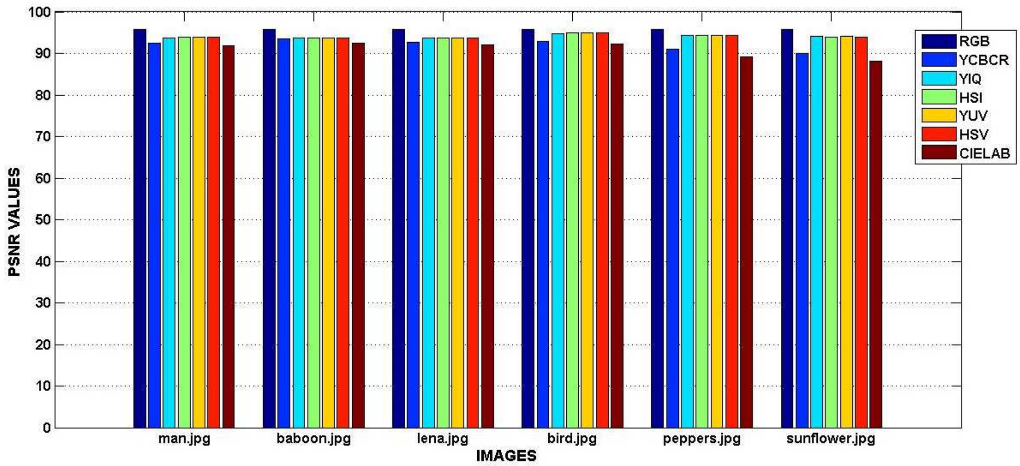

Figure 4: Bar Diagram Showing PSNR Values of Watermarked Images in Different Colour Spaces

In addition, by comparing different colour spaces, it is found that RGB colour space has the lowest MSE value as shown in Figure 5 and it equals to 4.48 and CIELab colour space has thehighest MSE value equals to 7.34 while after that, respectively, YUV, YIQ, HIS, HSV and YCbCrcolour spaces have the lowest values.

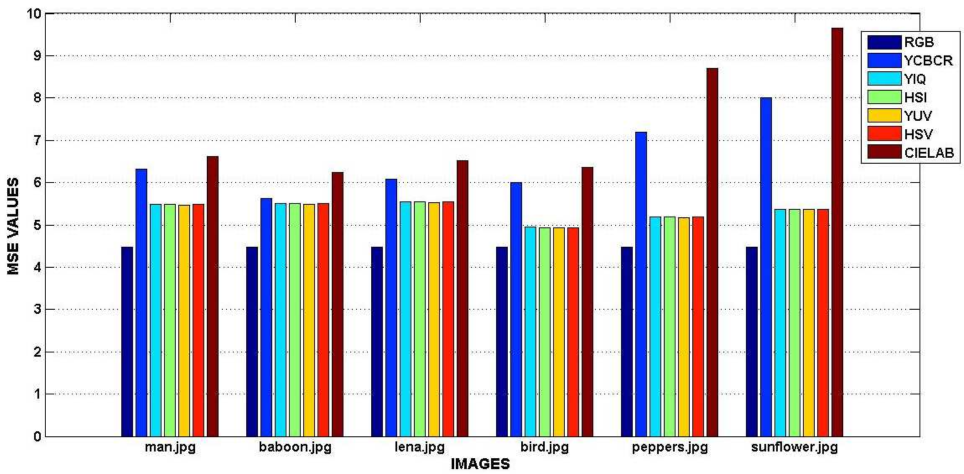

Figure 5: Bar Diagram Showing MSE Values of Watermarked Images in Different Colour Spaces

In this proposed approach it is found that RGB colour space has the lowest RMSE value as shown in Figure 6 and it equals to 2.12 while after that, respectively, YUV, HSV, YIQ, HSI, YCbCr and CIELab colour spaces have the lowest values.

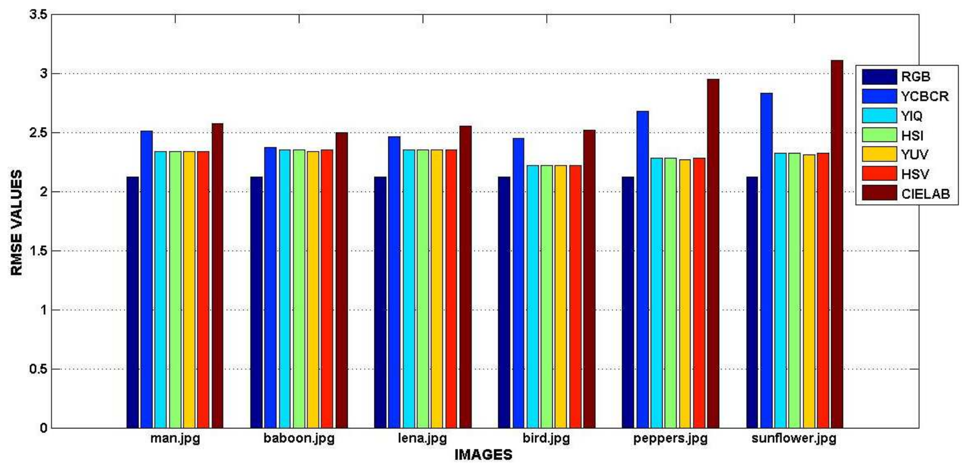

Figure 6: Bar Diagram Showing RMSE Values of Watermarked Images in Different Colour Spaces

CONCLUSIONS

In this paper, a joint DCT-DWT watermarking scheme was proposed and implemented in seven colour spaces: RGB, HSV, HIS, YCbCr, YIQ, YUV and CIELab in order to investigate the influence of colour spaces on image watermarking algorithm. The observations regarding the proposed watermarking scheme are organised as follows:

- It is found that the proposed image watermarking technique is undetectable to visual inspection i.e. there is no change found in the original cover image and the watermarked image as the watermark does not degrades the quality of original cover image.
- The experimental results show that RGB colour space has the highest PSNR value which means that the watermarked image is similar to the original cover image.
- It is seen that RGB colour space has the lowest MSE and RMSE value which implies that using this colour space for watermarking gives the lowest error and thus giving better watermarked image quality.

It is concluded that RGB colour space is the most effective in the proposed image watermarking algorithm and satisfies the imperceptibility property more than the other colour spaces. Then, YUV colour spaces satisfies this requirement.

REFERENCES

1. M. Khalili and D. Asatryan (2013). Colour Spaces effects on improved discrete wavelet transform based digital image watermarking using Arnold Transform Map. IET Signal Process, 7, 177-187.
2. R. Dubolia and R. Gupta (2011). Digital Image Watermarking by using DWT and DCT and Comparison based on PSNR. *IEEE Communication Systems and Network Technologies*, 593-596.
3. F. Lusson and K. Curran (2013).A novel approach to digital watermarking, exploiting colour spaces.*Elsevier Trans. on Signal Processing*, 1268-1294.
4. N. Bhargava et al. (2012). Digital Image Authentication System Based on Digital Watermarking.*IEEE Trans. on Radar, Communication and computing*, 185-189.

5. A. Sharma and A. Ganguly (2012).Image Watermarking in DCT-DWT Domain. IRNet Trans on Electrical and Electronics Engineering, 1, 1-5.
6. N.V. Dharwadkar et al. (2012). The Image Watermarking Scheme Using Edge Information in YCbCr Colour Space. *Proc. 3rd International Conf. on Information Security and Artificial Intelligence*, 56, 1-7.
7. M. Jiansheng et al. (2009). A Digital Watermarking Algorithm Based on DCT and DWT. *Proc. International Symposium on Web Information Systems and Applications,* 104-107.
8. S.P. Singh et al. (2012). A Robust Watermarking Approach using DCT-DWT. IJETAE, 2, 1-6.
9. S.K. Amirgholipour and A.R. Naghsh-Nilchi (2009). Robust Digital Image Watermarking Based on Joint DWT-DCT. IJDCTA, 3, 1-13.
10. Ali Al-Haj (2007). Combined DWT-DCT Digital Image Watermarking.Journal of Computer Sciences, 3, 740-746.
11. R.V. Totla and K.S. Bhapat (2013). Comparative Analysis of Watermarking in Digital Images using DCT and DWT.International Journal of Scientific and Research Publications, 3, 1-4.
12. N. Chaturvedi and Dr. S.J. Bahsa (2012). Comparison of Digital Image Watermarking Methods DWT and DWT-DCT on the Basis of PSNR. IJIRSET, 1, 147-153.
13. K. D. Megha et al. (2013). Digital watermarking: Data Hiding Techniques using DCT-DWT Algorithm. IJARCCE, 2, 2397-2402.
14. R. Anju and Vandana (2013). Modified Algorithm for Digital Image Watermarking Using DCT and DWT. IJICT, 3, 691-700.
15. M.J. Joshi, et al. (2011). Watermarking in DCT-DWT Domain.IJCSIT, 2, 717-720.
16. N. Goel and N. Chandra (2013). Analysis of Image Watermarking Algorithms. International Journal of Computer Applications, 65, 14-17.
17. A.A. Saleh and M.A. Abdou (2013).Evolutionary Computation Methods in Image Watermarking.International Journal of Computer Applications, 63, 1-6.
18. M. Yuvaraj et al. (2010). An Efficient Optimization Technique for Digital Watermarking in Image Processing. IEEE *Conf on Intelligent Control and Information Processing*, 803-808.
19. Dr. V. Singh (2011).Digital Watermarking: A Tutorial.Cyber Journals in Science and Technology, 10-21.
20. M. Ramaiya and R. Mishra (2012).Digital Security using Watermarking Techniques via Discrete Wavelet Transform.National Conference on Security Issues in Network Technologies, 1-8.
21. Lin Liu (2010) ece.sunysb.edu
22. N. Goel and N. Chandra (2013). Analysis of Image Watermarking Algorithms. IJCA, 65.
23. M.S. Smitha Rao, et al. (2012).Digital Watermarking: Applications, Techniques and Attacks. IJCA, 44.
24. C.T. Hsu and J.L. Wu (1999). Hidden Digital Watermarks in Image. IEEE Trans. On Image Processing, 8, 1-11.

25. R.K. Sharma and S. Decker (2001). Practical challenges for Digital Watermarking Applications. IEEE Trans. On Image Processing.

26. Mahmoud El-Gayyar (2006). Digital Rights Seminar on Watermarking Techniques. Media Informatics, University of Bonn, Germany.

27. C.I. Podilchuk and E.J. Delp (2001). Digital Watermarking: Algorithms and Applications. IEEE Signal Processing Magazine, 33-46.

28. R. Barnett (1999). Digital Watermarking: Applications, techniques and challenges. Electronics and Communication Engineering Journal, 173-183.

29. F. Hartung and M. Kutter (1999). Multimedia Watermarking Techniques. Proc. of the IEEE, 87, 1079-1107.

30. P.M. Naini, Engineering Education and Research in Image Watermarking using MATLAB.

31. Y.J. Song and T.N.Tan (2000). Comparison of Four Different Digital Watermarking Techniques. Proc. of IEEE on signal processing.

32. J. Abraham (2013). A Multi-purpose Dual Watermarking Scheme. IJCA, 77.

33. M. Narang and S. Vashisth (2013). Digital Watermarking using Discrete Wavelet Transform.IJCA, 74.

34. P. Dabas and K. Khanna (2013). A Study on Spatial Domain and Transform Domain Watermarking Techniques. IJCA, 71.

35. C.C. Ramos, et al. (2011). Watermarking-Based Image Authentication System in the Discrete Wavelet Transform Domain, Discrete Wavelet Transforms - Algorithms and Applications.

36. S.L. Hsieh et al. (2007). A colour image watermarking scheme based on secret sharing and wavelet transform. IEEE, 2143-2148.

37. Na Wang and Chung-Hwa Kim (2009). Colour image of tamper detection and recovery using Block-based watermarking. IEEE, 1-6.

38. Wadood Abdul et al. (2010). Watermarking using multiple visual channels for perceptual colour spaces. Proc. of IEEE 17th International Conference on Image Processing, 2597-2600.

39. Ming-Shing Hsieh et al. (2001). Hiding Digital Watermarks using Multi-resolution Wavelet Transform. IEEE Trans. on Industrial Electronics, 48, 875-882.